

ANNUAL REPORT

OF THE

CANAL ZONE

**Plant Introduction
Gardens**

For the Fiscal Year
1928



THE PANAMA CANAL ZONE
BOTANY DIVISION
1928

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For additional copies of this publication address The Panama Canal, Washington, D. C.,
or Balboa Heights, Canal Zone.

LETTER OF TRANSMITTAL.

CANAL ZONE PLANT INTRODUCTION GARDENS,
SUMMIT, C. Z., *July 16, 1928.*

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Canal Zone Plant Introduction Gardens, for the year ending June 30, 1928.

Respectfully,

J. E. HIGGINS,
Agronomist in Charge.

Mr. ROY R. WATSON,
Acting Chief Quartermaster,
Balboa Heights, Canal Zone.



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ANNUAL REPORT

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CANAL ZONE PLANT INTRODUCTION GARDENS FOR 1928

BY

J. EDGAR HIGGINS, *Agronomist in Charge.*

GENERAL STATEMENT.

The period covered by this Report is slightly over one year. The writer assumed charge of the agricultural work in the Canal Zone on May 11, 1927. A very brief statement of the affairs of the Plant Introduction Gardens was submitted at the close of the last fiscal year to cover the period from May 11 to June 30. This was not recommended for publication. The present report therefore has been made to cover a few weeks at the close of the year

OBJECTIVES.

It may be well, at the beginning, to take a general view of the work, as now conducted, in order to get its perspective and to understand its aims and objectives.

The Canal Zone is a narrow strip of land under the control of the United States of America and existing, as such, for the single purpose of maintaining and operating the Panama Canal. Its character is, therefore, unique among all the States, Territories, or other units over which flies the American flag. Its existence is not dependent upon agriculture, mining, fisheries, manufactures, or any other industries, operating upon its terrain, in its streams, or along its shores. Nevertheless no country can be complete without some sort of agriculture, no matter how fully its financial resources may come from commerce. If any one doubts this statement let him picture to himself a region devoid of all that grows out of the soil. Take away the trees, the shrubs, the vines, in short all the plants with their fruits and other food products, their grateful shade

and beauty and that which remains is an uninviting waste in which no man would care to live. Although nature, unaided, can produce a jungle in these tropic lands, the hand of man is necessary to select plants for his needs and satisfaction and to transform the jungle into gardens, orchards, and plantations. This is agriculture.

The authorities, to whom have been committed the responsibilities of governing the Canal Zone, have clearly perceived the importance of making life on the Isthmus more than a mere existence and have not only transformed this little strip of land into one of the cleanest and most sanitary places on earth but have made clubhouses, swimming pools, and the like as regular a part of the program as fuel oil tanks and electric power. In part for the same reason, agriculture has not been overlooked and a center of agricultural activity was established at Summit and given the name of the Canal Zone Plant Introduction Gardens, in full recognition of the fact that trees and vines, fruits and flowers, as well as all the economic plants, are vital to the life of the Isthmus.

But the vision of those responsible for this action must certainly have extended far beyond the confines of this narrow strip of country. Stretching away to the Northwest, to the South, and to the East lie, dormant, vast undeveloped agricultural resources, capable of producing rubber, sugar, fiber plants, pineapple, and a score of other tropical products. In future years, when man has drawn the last drop of oil from nature's storehouses, it is not improbable that these tropical lands will produce the supplies of fuel alcohol to operate the world's commerce and industry. For out of the soil, scientifically managed, inexhaustible supplies of fuel can be created. Whatever may be done to develop agriculture in this little center can not fail to have its influence upon the surrounding countries. Already many visitors from these countries are calling upon us for information and for plants. In turn, whatever develops tropical agricultural production in Central America and South America tends ultimately to benefit the United States in increased commerce, increased supplies of raw products available for manufacture, and increased tariff receipts.

In considering the relation of agriculture to the Canal, it must not be forgotten that forestry is but a branch of agriculture, concerned with the care of plants en masse, usually where nature has placed them. The very water that makes possible the operation of the Canal is brought to earth from the passing clouds by the trees upon the mountains and hillsides. These trees are not immune to destruction as the people of the United States are learning from the devastations in the forests at home. It is not too soon to have it in mind that the necessity of protecting these forests may, at any time, become pressing.

The educational and recreative values of the Gardens are being more freely recognized by the residents of the Isthmus who find so few places to go and who are coming here in increasing numbers. Although the Gardens are only in their fifth year out of the jungle condition, they are beginning to attract the attention of visitors from many parts of the world. As the species of trees and plants of commercial culture in the tropics and the many rare and unusual tropical growths develop to maturity, they will constitute one of the attractive features for those who contemplate visiting the Isthmus.

That the need of such work as is being done at the Plant Introduction Gardens is a most pressing one in the opinion of those capable of judging the situation, may be gathered from a few quotations from no less an authority than Dr. Paul C. Standley, author of the recently published *Flora of the Panama Canal Zone*.¹ In speaking of introduced plants in the Isthmus he states:

"There is probably no region of Central America which exhibits so mediocre a selection of horticultural or ornamental plants as does this part of Panama. Scarcely one garden plant of any special interest is seen about Panama City, all those planted being the most ordinary and widespread tropical ornamentals. These, it is true, are grown in quantity and often effectively. The wholesale plantations made by the United States Government about the Zone towns consist of monotonous repetitions of hibiscus, bougainvillea, crotons (*Codiaeum*), and *Nothopanax*.

"The sole exception, except for the plants grown at Summit, which are mentioned elsewhere, is the choice variety of trees and shrubs scattered about Gorgas Hospital. The best of them are a heritage from French days . . . "

Concerning the activities at the Plant Introduction Gardens which, at the date of Dr. Standley's writing were under the able direction of my predecessor, Mr. Holger Johansen, the author continues:

"About three years ago there was established by the Government of the Canal Zone at Summit, on the divide between the two oceans, a plant introduction garden under the direction of Holger Johansen. The garden has for its object the introduction of new plants with economic or ornamental possibilities, and Mr. Johansen has assembled a really remarkable variety of plants (about 1,000 species), considering the brief time he has been engaged in the work. As a result of this undertaking it is to be hoped that the ornamental plantings of the zone, which attract so much attention from tourists and other visitors, will assume a more instructive and varied character, and that agriculture and horticulture will be so stimulated that they may be a credit to the region. There is an exceptional opportunity for establishing in Panama all the best lowland tropical plants, and for testing new plants which may add materially to the wealth of this and other parts of Central America. When it is remembered that the prosperity of Central America is dependent primarily upon the growth for export of two crops, coffee and bananas, and that the latter industry is threatened with ruin, the importance of diversification in Central American agriculture can not be emphasized too strongly."

¹ Smithsonian Institution, United States National Museum.
Contributions from the United States National Herbarium Vol. 27. Govt. Printing Office, Washington, D. C., 1928.

The man lacking in vision has always had difficulty in seeing any special use in spending Government money in botanic gardens and has always clamored for these institutions to become self-supporting. But let it be remembered that these Government-supported botanic gardens have been to a large degree the agencies through which the British, the Dutch, the French, and other European nations have initiated their great colonial agricultural industries. Shortsighted men in the United States have had a similar warped idea about the American agricultural experiment stations and agricultural colleges. But the day of these men is passing and both Federal and State Governments are now spending money by the millions in the support of these institutions and are recognizing that money so spent has brought back a large return.

Keeping in view all of these larger aspects of the relation of agriculture to the Canal, as well as the more intimate relationships with which we are familiar, if the United States were spending several hundreds of thousands of dollars annually in tropical agricultural investigations in the Canal Zone, as a center, it is probable that every dollar would ultimately return to the Treasury increased many fold, for the nation is the greatest consumer of tropical products.

Therefore, the objects of this agricultural station to which has been given the name Plant Introduction Gardens must be larger than the introduction of plants and, so far as its very limited resources will permit, must be engaged with any and all problems that pertain to the development of the plant life of the region, whether these be concerned with the fostering of a rubber industry or the introduction of a beautiful shade tree or a new variety of tomato. Being the only public agricultural activity here, the institution combines the features of an agricultural experiment station and a botanic garden. In the future when the permanent plantings of economic and ornamental plants have attained maturity, they should constitute one of the outstanding features of the Canal Zone. An aeroplane view of the Gardens, is shown in Plate I.

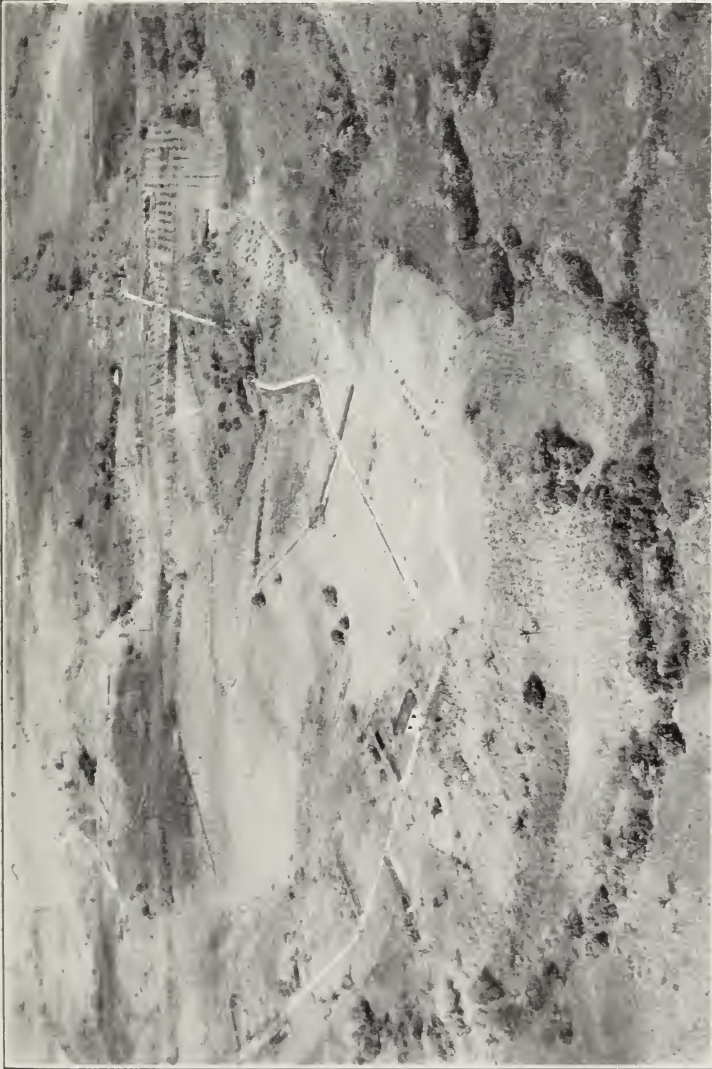
CONDITION OF PLANTS AND THE AGRICULTURAL PROBLEMS PRESENTED.

In general, the permanent plantings at the Gardens have made very satisfactory growth. It will be impossible to report upon each of the hundreds of species separately but a few of them may be covered in this report and some of the problems arising out of their culture.*

THE MANGO.

The mango, at its best, has few rivals in excellence, among all the varied fruits of the tropics. Yet there are few among the people who

PLATE I.



Aeroplane view of the Canal Zone Plant Introduction Gardens.

dwell in the Western Hemisphere who have ever known this fruit at its best. The seedling mangoes found so abundantly at low altitudes throughout the West Indies and the American tropics, although in many instances of good flavor, fall far short of the excellence of the best varieties of India which have been propagated for centuries by grafting. The mangoes of the Occident in general, are far excelled also by the Philippine mango and probably others of that race. Many of these choicer Oriental varieties have been introduced into the Western tropics but until now have been so little disseminated that very few people are acquainted with them. The common seedlings are no more comparable with these choicest varieties than were the seedling cider apples of our boyhood days with the leading commercial sorts of to-day.

THE MANGO ORCHARDS.

The mango orchards have made very good progress and many of the young trees are beginning to bear fruit. (Plate II, Fig. 2.) Among the varieties now in fruit may be mentioned the Sandersha, Saigon, Kavasji Patel, No. 11, Cambodiana, Mango de Rosa, Jamaica seedling, Ancon, Kala Alphonse, Baboony, Hayden, Ohlson, Totafari, Amini, Juan Mina.

The Sandersha at the date of this writing, is one of the few varieties among the grafted trees which have matured fruit this season. (Plate III.) Several trees of this variety produced a little fruit in the year 1927 also. It gives evidence of being one of the most precocious and productive of the varieties in the Isthmus. It is of very large size and strikingly beautiful appearance, having an attractive yellow color while still immature, the exposed side being bright pink. It is comparatively free from fiber and of fair quality as a dessert fruit, although not equal to the best of the Oriental mangoes. As a mango for culinary purposes it is one of the best, the mango sauce made from the hard fruits being of high quality. In this form it might offer some possibilities as a canned product, its heavy yield making it possible to sell it at a comparatively low price. The Sandersha, unfortunately, is very susceptible to mango anthracnose, which is described below. Those few fruits which ripen before the rains have become frequent are clean and handsome but nearly all the crop ripens in the rainy season. They do not appear to be seriously affected by splitting and spotting while on the tree but before they have become soft enough to eat uncooked, whether on the tree or in the ripening room, black spots and decay injure large areas and destroy the market value completely. If used for culinary purposes as stated above, the injuries from anthracnose would not be so serious as the hard fruit is not much affected. Unless the Sandersha can be protected with fungicides, which



FIG. 1.—Water Lilies. *Nymphaea Lotus var. dentata*.



FIG. 2.—Mango Orchard. Planted May, 1924.

is difficult during torrential rains, or can be induced to fruit earlier and mature its crop before the heavy rains begin, this variety will be of little value for fresh fruit under Isthmian conditions.

The Cambodiana and its near relative the Saigon, each matured a few fruits in the rainy season of 1927 and are again in fruit at this time. The fruits are of medium size, yellow in color, free from fiber and have a distinctive, subacid, aromatic flavor very attractive to most lovers of the mango. Because of a certain degree of resistance to anthracnose which seems to be inherent in the fruits of the Cambodiana race, as observed here and elsewhere, its varieties are among the most promising for culture in the Isthmus where rains prevail during the normal ripening season.

The Kavas ji Patel is one of the largest mangoes known and excellent in appearance. The one or two fruits gathered in 1927 were good specimens of the variety but were affected with anthracnose. As is true of most of the varieties, it is yet too soon to pass judgment upon its local adaptability.

The Corozal, a mango of local seedling origin, and now propagated asexually, gives some evidence of precocity and of high productivity. It is bearing heavily this year and bore also in 1927. The fruits are of medium to large size, saffron yellow in color of skin and fine in appearance when free from anthracnose. The flavor is fair.

The Pairi (Syns., Pirie, Pyrie, Paheri, etc.), which is one of the best mangoes known, has not yet matured fruit at these Gardens. The advent of fruit of this variety is awaited with much interest. It is of medium size, yellow skin with a scarlet blush on the exposed side and yellow orange flesh which is so free from fiber that the fruit can be cut transversely and separated into halves, the seed being easily removed. The flavor is unique and most delicious.

The Carabao (Syns., Philippine, Manila), likewise has not yet fruited. This also is one of the most famous mangoes of the world and its fruiting here is awaited with much interest.

THE DISEASE PROBLEM.

The mango is so vigorous, under conditions existing in this region, that it springs up almost like a weed and persists through drought and even ranging grass fires. Nevertheless, there are some very important problems that must be solved before the commercial production of mangoes can be founded upon a secure and profitable basis. The chief of these problems grows out of the presence of a disease which is almost coexistent with the mango but, because of certain climatic conditions, constitutes more of a problem here than in some other mango regions.



Young Sandersha Mango Tree in Fruit.

This disease is commonly known as Mango Anthracnose and is caused by a fungus which is recognized by some plant pathologist as *Colletotrichum gleosporioides* Penz, although there has not been unanimity of nomenclature. This organism grows very rapidly, during rainy weather, and causes great damage to fruits, flowers, and young growth that may be presented at such times. It frequently destroys completely any flowers or new flush of leaves that may be present. Very young fruit may drop from the tree and older fruit may drop or split or become spotted, the ripening fruit presenting the very familiar and disfiguring black spots which destroy its commercial value for any exacting market and cause it to decay.

Resistant varieties.—One of the possible means of avoiding the damaging effects of this disease may lie in the use of resistant varieties. The fruit of many of the varieties of the Cambodiana race of mangoes offers a considerable degree of resistance to the disease. This race is represented at the Gardens by the varieties, Saigon, Carabao (Syn., Manila), the Cambodiana itself and probably others. Some of these are in fruit this season and will be carefully observed with reference to disease resistance at the time of ripening.

In dry weather the Mango Anthracnose does not develop to a degree sufficient to do any serious damage. Hence in those regions where the mango tree opens its flowers and matures its fruits during the dry season, the crop is clean and uninjured. This is true to a considerable degree in some of the mango growing sections of the Philippines which fact in part accounts for the fame of the Manila or Philippine mango. In the Isthmus of Panama, even on the Pacific slope where the dry season is very pronounced, this does not synchronate quite accurately enough with the flowering and fruiting seasons of the mango. This fruit tree is somewhat erratic in its flowering habits and may produce bloom at almost any time from late December to early April but there appears to be a tendency toward two chief seasons, one about the first of the year and a second in March, the latter predominating. As both of these periods are during dry weather, the flowers escape the rains, and, other factors being favorable, are likely to start a good crop. The fruit that results from December or early January flowers will mature before the heavy rains begin and will not be much injured by anthracnose. But flowers that open in March, which is the prevailing season, although escaping the unfavorable weather themselves, can not develop into mature fruits until about July, and then the heaviest rains must be encountered. The result is that a large part of the crop is destroyed either on the trees or in the process of ripening.

THE POSSIBILITY OF CONTROLLING THE FLOWERING SEASON.

For these reasons it would be most desirable if any treatment could be found which would induce flowering in late December or early January so that neither flowers nor fruit would be present in rainy weather which usually begins on the Pacific slope about the middle of May and ceases in the early part of December.

In an attempt to bring about early flowering, certain treatments have been applied to a few trees during the fiscal year just closed. Because of the lack of a sufficient number of trees of one variety, and otherwise offering uniform conditions, it was not possible to conduct these experiments on a sufficiently large scale, or with sufficient uniformity of the factors involved to eliminate all doubt of the significance of the results. Nevertheless the latter are sufficiently striking to be worthy of recording and may be considered as suggestive of further and more accurate experiments.

The mango tree forms its flowers almost exclusively from terminal buds. The tree produces a vigorous vegetative growth during the rainy season and terminal buds are pushed rapidly into vegetative growth and do not become differentiated into flower buds. Not until the rains have abated does this growth become retarded or discontinue. Then with a reduced moisture supply at the roots and an accumulated supply of elaborated material in the tree, fruit buds are formed at the ends of the branches. As stated above a few flowers appear in the early part of January or even in December but most of the buds are not ready to open until March or late February.

It would be desirable if any treatment could be devised which would induce a general flowering in late December or early January so that neither flowers nor fruit would be present in rainy weather which usually begins on the Pacific slope about the middle of May and ceases in the early part of December. One means by which such a result might be sought is root-pruning. The severing of a large number of the minor roots cuts off a part of the excessive supply of moisture and if this limitation is maintained the so-called moisture, nitrogen, carbohydrate ratio is altered in a manner favorable to fruit production by the reducing of the proportion of moisture and also the intake of nitrogen. Hence experiments in root-pruning during rainy season are suggested.

Again, the ration of moisture, nitrogen, and carbohydrates in the upper part of the tree may be altered by girdling a part or all of the tree. This results in preventing the free flow to the roots of carbohydrates elaborated in the leaves and thus increases the proportion of carbohydrates in the ratio. For this reason it also retards root growth and

thus tends to reduce the excess of moisture. Hence experiments in girdling in rainy season are suggested as another possible means of bringing about flowering at the desired season.

TESTS OF ROOT-PRUNING AND OF GIRDLING.

The experiments, conducted at the Gardens, made a test of root-pruning and also of girdling. Tree No. 1 was root-pruned. This tree is an old and isolated seedling at the northwestern end of the Gardens and is reported to have fruited in the year 1926 but not in 1927. On October 18, 1927 the tree was root-pruned by digging a trench around it to a depth of 18 inches and just inside the spread of the branches. This trench was left open until January 21 when the soil was replaced.

A group of three trees at the east side of the Gardens was selected for further tests. These are rather close together in the form of a triangle, some of the branches intermingling. Of these, the tree designated No. 4 was root-pruned, at the same time and in the same manner, as tree No. 1, and the trench remained open until January 21, 1928. Tree No. 3, located in this group, was completely girdled on October 28 by the removal of a ring of bark, approximately 2 inches wide, from the trunk at a height of 4 feet from the ground. By January 31 this girdled space had been completely bridged over at two points in vertical areas varying from 1 to 2 inches in width. The deposition of new tissue, tending towards bridging had begun at many points. The remaining tree of this group of three, designated tree No. 2 received no root-pruning or girdling and may be considered as a check, in so far as one tree among three or four could serve as such.

There was a somewhat general flushing of new growth on mango trees at the Gardens about January 1 and a very few flowers were in evidence. One or two flower clusters appeared on the trees under experiment but no growth or flowering of any importance on the treated trees or the one which received no treatment. In external appearance they all seemed to be in a comparatively quiescent condition.

BREAKING THE REST PERIOD.

It was desired to break this so-called resting period and force the opening of the buds, many of which it was believed might have become differentiated into flower buds by that date. In the hope of doing this, smudge fires were lighted under tree No. 1 and in the center of the group of trees Nos. 2, 3, and 4. This smudging began on January 4 and was continued with some intermissions until January 20, the fuel used being composed to a large extent of fresh grass and other slow-burning materials. Palm leaf wind breaks were used to prevent the smoke and heat from

being blown away before rising through the trees. The conditions were adverse for smudging as rather strong breezes were blowing much of the time, from shifting directions.

TREE NO. 1. (ROOT-PRUNED.)

On January 25 it was observed that a very profuse flowering was beginning on all parts of tree No. 1 except the upper part of the southeast quarter and here the tree was coming into a flush of new leaves. In the other parts nearly every terminal was beginning to open a flower cluster. Many of these flower clusters showed a rather unusual appearance in that they bore leaves or bracts several inches long and subtending the various branches of the cluster, illustrating that the flower cluster is morphologically a branch in which the axillary buds and the terminal have been transformed from vegetative to reproductive organs. A heavy crop of mangoes began to develop.

Irrigation.—In February, it appeared that it would be necessary to apply water to this tree that was so heavily laden with fruit. As the Gardens are not equipped for irrigation of mangoes, special arrangements were improvised and water was applied February 23, March 12, and April 11.

Fertilization.—An application of 5 pounds of sulphate of ammonia was made on March 9.

Further results.—Whether for lack of sufficient nourishment or water or for other cause a considerable part of the excessively heavy crop of this tree fell. In fact it would have been impossible, with the best of feeding, for the tree to have matured over 50 per cent of the initial setting of fruit. However, a fair crop was brought to maturity and began to ripen on May 15 and by May 19 about 50 per cent of the fruit on the tree was ready to harvest, the balance following within a few days. This was a little too late to entirely escape the rains but the fruit was comparatively free from anthracnose.

TREE NO. 3 (GIRDLED) AND TREE NO. 4 (ROOT-PRUNED).

These were observed to be opening their flower buds on January 28, each presenting a most remarkable number of fruit buds, the root-pruned tree rather excelling in this respect. As these flower clusters developed, they presented the same peculiarity of formation as recorded in the case of tree No. 1.

Irrigation and fertilization.—It was possible to get water to these two trees, for the first application, on February 9 and this was repeated on February 24, March 12, and April 11. An application of 5 pounds of sulphate of ammonia was given to each of these two trees on March 24.

Each of these two trees carried a heavy crop of fruit to maturity in the latter part of the month of May. This was a little late to escape all of the rains but the fruit was comparatively free from disease.

Tree No. 2 which was neither root-pruned or girdled but which received the same smudging as No. 3 and No. 4 presented no flowers until the early part of April when rather a sparse flowering appeared. These fruits can not mature until August. The rains began soon after the period of flowering.

Interpretation of these results.—While the results of these simple tests are consistant and point toward the effectiveness of the operations performed as a means of hastening the flowering and fruiting seasons, further trials would be required to justify definite conclusions.

The process of smudging mango trees has grown up, on an empirical basis, in the Philippines, among mango growers who have found that trees that have been long enough in a quiescent condition, can, by this practice, be forced to open their flower buds. The high prices paid for the early fruit, which also is clean, are sufficient to well pay for the additional expense involved in smudging. Fifteen to 25 cents (gold) each is not an unusual price for these early fruits.

Until recent years scientists, so far as they have given any attention to the subject, have been inclined to the belief that any apparent results in flowering were attributable to the control of leaf-hoppers (Jassidae). To obtain accurate scientific data on this subject, Gonzalez, at that time a candidate for the degree of Master of Science in the University of the Philippines, undertook a thesis study of this subject and arrived at experimental results coinciding with those that have been arrived at empirically, and indicating that the effects could not be attributable to insect control.¹ Gonzalez concluded that the increases in temperatures were the probable cause of flowering. These increases he found to be in some cases over seven degrees centigrade. He called attention to the well-known fact that a branch of a dormant deciduous tree, in midwinter, may be conducted through a small opening into a warmed greenhouse and thus be forced into flowering while all other parts of the tree remain in their winter dormancy.

It is not at all impossible, however, that the gases of the smoke may be to a large degree responsible for the opening of flower buds on smudged mango trees. In recent years gases, resulting from the incomplete combustion of gasoline and kerosene, have been used in the ripening of the fruits of citrus, bananas, tomatoes, and other plants. This is merely an accelerating of natural processes which otherwise would proceed more slowly and therefore is analogous with any hastening of the

¹ Gonzalez, Leon G. "The Smudging of Mango Trees and its effects. With a prefatory note by Professor J. Edgar Higgins," Philippine Agriculturist Vol. XII, No. 1, 1923.

maturing or opening of flower buds that may be brought about by artificial means. For this purpose of ripening fruit, smoking lamps or stoves are used or the gases conducted from the exhaust pipe of a gasoline engine. More recently ethylene gas sold in drums is replacing the earlier and cruder methods.

The effects of these gases are more than a mere breaking down of the chlorophyll and a consequent yellowing of the fruits. Real ripening processes take place at least in some kinds of fruits. Perfectly green tomatoes, picked from the vines, and treated with the gases from a smoking lamp can be ripened in a few days so that it would be difficult, if at all possible, to detect any difference between these and vine-ripened fruits. Denny¹ has demonstrated very effective results in breaking the rest period of dormant potato tubers by means of vapors or solutions of various chemicals, ethylene chlorhydrin proving to be most effective. All of these effects amount to an acceleration of the natural processes and are analagous to hastening the fruiting period. These results, combined with those of Gonzalez, referred to above, and also with these referred to in the experiments reported above, suggest that the gases, resulting from incomplete combustion, may be, in part or entirely, the cause of the breaking of the rest period of mango buds by smudging.

If this be true, the application of gas to mango or other fruit trees might be applied under a tent as in fumigation in a manner much more expeditious and economical than the crude method of smudging.

CONCLUSIONS.

1. The results of the experiments with mango trees, recorded above must be regarded as suggestive rather than conclusive, as, unavoidably, there were too many variant factors.

2. It is fair to state that all the evidence in hand points toward the feasibility of advancing the mango season.

3. Root pruning or girdling, combined with smudging was followed by a heavy flowering and setting of fruit, as the few trees so treated produced flowers and set fruit in greater abundance than any other of the many mango trees in the Gardens, and at a time when very few trees were producing in the Canal Zone.

4. On the question of the effectiveness of smudging alone, the only evidence in hand is that of the one tree which was smudged only, not having been previously treated to change the water-nitrogen-carbohydrate ratio. As this tree did not flower, while all the others involved flowered profusely, this slight evidence points toward the ineffectiveness of smudging alone, in any attempt to hasten flowering in a tree that has

¹ Denny, F. E. Hastening the Sprouting of Dormant Potato Tubers. Contrib. Boyce Thompson Institute for Plant Research Vol. 1, No. 2. See also Vol. 1, Nos. 3 and 4.

continued its vegetative processes, uninterruptedly, with abundant moisture. Since it produced practically no flowers, such meager evidence as it affords, does not encourage the use of smudging on trees that have not been prepared for it either by natural or by artificial means.

5. As all of the trees in the experiment were smudged, there is little or no evidence to indicate whether smudging had any influence in causing the flowering of the girdled and the root-pruned trees in January. In all of the three cases of heavy fruiting out of season, one other factor was involved with the smudging which makes it impossible to conclude whether the smudging or the other treatment or both were effective.

6. All of the evidence is sufficiently significant to suggest the importance of accurate studies under uniform conditions, first to determine what methods may best be used to induce the formation of fruit buds and second to find whether any methods of treatment by gas or otherwise would be effective in breaking the rest period at the desired season.

7. It is too early to make any recommendations, to growers of mangoes, in the matter of the application of girdling, root-pruning, or smudging, except that any such work should be done on an experimental scale only. Girdling should be tried by the orchardist on selected branches only. The ring of bark removed, should probably not be more than one-half inch in width and an incomplete girdle may suffice. The tree which was girdled in the experiment here recorded flowered much more profusely than would be desired in commercial culture. A good crop each year is far better than an exhausting crop once in two or three years. The wound made by girdling or incomplete girdling should be painted with asphalt paint or other protective covering. Many fruit trees would not endure such girdling as given in the experiment but the mango is exceedingly robust and vegetative. Root-pruning also should be carried on only as an experiment at first. However, the amount followed in the trials, at the Gardens, has not shown any detrimental results to date. The same may be said of the girdling but a full year has not yet passed. Root-pruning of the mango is not new, it having been practiced more or less in India for many years. Smudging can have no ill effects so far as known, if the fires are kept under control and not allowed to burn the trees.

AVOCADO.

The avocado orchard, at this station, has made as good progress as could be expected, considering the inadequacy of available irrigation. During the rainy season the trees make a good growth, but are greatly retarded from January to May when the weather is very dry. The only means available for getting water to these trees, now of bearing age, is a three-quarter inch hose.

Every effort has been made to conserve moisture, through the improvement of the soil by the application of manure, and also by the use of a heavy mulch of grass applied around each tree at the close of the wet season. But even with these precautions, the trees show a great lack of water. Most of the varieties normally flower during the dry season and without ample water they can not be expected to carry a crop of fruit successfully to maturity. It will be necessary to install some adequate system of irrigation, to maintain this orchard in health and in production.

There are very few if any places on the Pacific slope of the Isthmus where avocados may be safely planted without an irrigation system. The avocado is very sensitive in its relation to water. For real success it must have a rather liberal supply at all times. On the other hand it can not endure a lack of drainage. These two factors must be taken into consideration in selecting a location for avocado trees. There have been some failures, in avocado culture, in this region, because of the neglect of these precautions.

Another factor that the prospective avocado grower must take into consideration is the selection of varieties. Varieties for commercial culture must not only be of good quality and free from fiber but must "carry" well, that is they must not ripen too quickly after being harvested. They must also be productive and regular in bearing habits. But, one of the most important factors, in variety selection, on the Isthmus, must be the question of season. At times cheap seedling avocados are so abundant that it would be impossible to get the price for choice fruit that it would bring a few weeks earlier or later. Therefore choose what may be called the out-of-season varieties. Not much is known yet about the behavior of the different varieties of avocado, under Isthmian conditions, but it has been demonstrated that some of the Florida hybrids of the West Indian and the Guatemalan races, are late in maturing and may be harvested after the markets have been cleared of local fruits. Among these may be mentioned the Winslowson and the Collinson, both of which have matured at Pedro Miguel, late in the rainy season, long after local seedlings were out of the market. The Winslowson has also fruited heavily at Gamboa. The Simmonds is another Florida variety which holds its fruit until avocados are not plentiful in the market. None of these varieties has yet fruited at the Plant Introduction Gardens. In selecting varieties, with reference to seasons, a study must be made also of the marketing of Colombian and Haitian avocados and possibly others sold in this market. In the higher altitudes of Panama, the varieties of the Guatemalan race should be established. These tend to mature from November to March. By a careful selection of varieties and locations, it would be possible to have good avocados in the market at nearly all times of the year.

If the prospective avocado grower will make a wise selection of well-drained soil, near an adequate water supply, if it be in a dry region, the business of growing avocados for local use and for ships ought to be profitable. In some places on the Atlantic slope, it will not be necessary to provide for irrigation, but there are many localities where a mulch would be beneficial, during the months of least precipitation.

PINEAPPLE.

There are now under cultivation, at this Station, six varieties of pineapple. These, under their locally applied names are Taboga (known also as Choccona), Monte Lirio, Red Spanish, Cayenne, Queen, and Milagro. The true identity and origin of the Monte Lirio, the Taboga, and the Milagro varieties is not known. It is probable that a careful study of these and a comparison with standard established varieties would reveal that the locally used names are synonyms.

The Taboga or Choccona which appears to have been grown, for many years, on the Island of Taboga, in Panama Bay, has enjoyed some fame, even in distant parts of the world. This is probably due to the fact that travellers to Panama have found it the predominating pineapple and also because of its excellent flavor. The Taboga is a fruit of medium to large size, conical or tapering in shape, many fruits being distorted or unsymmetrical, which is said to be due to insect attacks. The "eyes" or surfaces of the fruitlets, are flattened which is in its favor but the color of the exterior is rather too pale a yellow to compare favorably with some of the other kinds. The flesh is nearly white and, to one not accustomed to this variety, is likely to convey the idea of immaturity. In flavor and juiciness, the Taboga ranks high but there is too much coarse fiber in the flesh. From the standpoint of the plant-breeder, it is well worthy of a place but for commercial purposes, it is likely to be replaced by other varieties.

The Cayenne.—This is the leading pineapple of the world, for canning purposes, and is the basis of the Hawaiian pineapple industry. It is represented at the Gardens by only a few plants but these are being multiplied as rapidly as possible. The fruits are large, those well-grown of the first crop, probably averaging above six or seven pounds, while specimens not infrequently weight 12 pounds and much larger ones are reported. The fruit is barrel-shaped with a tendency in some strains to become conical. The eyes are flattened. The color of exterior is a bright yellow and the flesh is a light golden yellow. It is comparatively free from fiber and has a small core. The juice is very abundant and of good flavor. This is, preeminently, a variety for canning or for very near

markets as its large size, tender flesh, and abundant juice make it a poor shipper. For growing in the Isthmus for local consumption or for supplying ships, it will probably prove to be of the best. The few plants that have been growing and fruiting at this station seem to indicate that the variety will prosper here. It is very desirable that there should be introduced into the Isthmus, a fair supply of the several strains of the Cayenne that are now known to exist.

The Monte Lirio (Plate IV).—This is a local name for a variety which has been grown for some time about the District of Monte Lirio. It closely resembles one of the strains of Cayenne and is giving promise of being one of the best pineapples in our collection. The small plantation at the Gardens has been yielding abundantly, the height of the season being June.

The Spanish or Red Spanish.—This may be considered as the standard variety for shipping as fresh fruit. The fruit is of medium size, short and thick, the diameter frequently being equal to the length. The “eyes” are very large and flattened. The color of exterior is a yellowish red which gives rise to the name “Red Spanish” by which the variety is frequently known. The flesh is firm, crisp, of good flavor, and sufficiently juicy. There is a characteristic flavor that appeals strongly to some tastes. Upon this variety is based the prosperous pineapple industry of Porto Rico. It is also the leading variety in Cuba. It is a hardy plant, yielding abundantly, fruit well adapted to shipping. If a fresh fruit pineapple trade with the United States or Europe is to be built up here or anywhere in Central America, it will be difficult to find a better variety for the purpose than the Spanish. To attempt to build up such a trade upon the Taboga or the Cayenne is somewhat hazardous unless special shipping facilities can be provided.

Through the kindness of the Port Limon branch of the United Fruit Company, the Canal Zone Plant Introduction Gardens received, in October, 1927, about five thousand plants of the Spanish variety. These are making an excellent growth and will constitute the beginning of a good source of supply for the Isthmus.

The Queen.—This is a variety of small to medium sized fruit, inclining to long or cylindrical shape with prominent “eyes” and a handsome light yellow color. The flesh is perhaps one of the most tender, crisp, and delicious to be found among the pineapples and, as a home garden variety, it is well worthy of a place. The Gardens are indebted to the Port Limon branch of the United Fruit Company for several hundred plants also of this variety which arrived in October and are now growing well.

PLATE IV.



Field of Pineapples of the variety "Monte Lirio."

Milagro.—This is another smooth leafed variety, the identity of which is not known. It was introduced from Ecuador by Mr. Holger Johansen, under the name of the district in which it was found. Its characters have not yet been closely studied at the Gardens.

Possibilities of an extensive pineapple industry.—Inquiries have been made by several interested parties concerning the possibilities of establishing the pineapple industry here on a large scale. There are two possible phases of such an industry, the one based upon the canning of the fruit and the other upon fresh fruit shipping. It has sometimes been assumed that the journey from Panama to the American markets is too long for successful marketing of fresh pineapples. This, however, appears to be a wholly unfounded assumption. The run from Panama to New Orleans is approximately the same as that from Porto Rico to New York and a very successful and highly profitable pineapple shipping business has been maintained on the latter route for many years. New Orleans, besides being a good market itself, is an excellent distributing center for the South and the West. Several lines of steamships make the run to New York in six to seven days which is not at all an excessively long trip for pineapples of the Spanish variety even without refrigeration. It has been demonstrated in Porto Rico ¹ that pineapples of this variety, even if coloring when harvested, may be kept at a temperature of 40 degrees Fahrenheit for 15 days, with only a slight increase in coloring and the fruit remaining firm and excellent for sale. This time would suffice to get fruit to Europe as some boats now make this trip in 14 days.

As long ago as 1907, the Hawaii Agricultural Experiment Station, in cooperation with several pineapple-growing companies, successfully shipped Cayenne pineapples from Hawaii to Chicago, the period in transit from field to market being about 21 days.² In this case a refrigerator car was used from San Francisco to Chicago. A leading fruit dealer in Chicago pronounced the pineapples in good condition to be forwarded to New York.

With these data in mind, it ought not to be considered at all difficult to ship the Spanish pineapple, in suitably equipped steamships, from Panama to New Orleans or to New York, if proper methods are employed.

The establishing of a pineapple canning industry in this region is another possibility that merits very careful study. The growth of this industry in Hawaii has been quite phenomenal and the demand for canned pineapple has kept well up with the production. The available pineapple lands in Hawaii are practically all occupied and much further ex-

¹ Henrickson, Henry C. "Some Pineapple Problems". Agricultural Notes No. 42, Porto Rico Agricultural Experiment Station, Mayaguez, Porto Rico.

² Higgins, J. Edgar. "Fruit Marketing Investigations in 1907." Hawaii Agricultural Experiment Station, Press Bul. No. 21.

pansion there seems impossible. It is well known that the large pineapple growing corporations of Hawaii have been investigating the possibilities of other countries as a base for expansion. The opportunities here for Hawaiian or other capitalists who are interested in pineapple production are worthy of careful investigation.

The brief period during which the Cayenne and the Spanish varieties of pineapple have been under observation at the Plant Introduction Gardens is not sufficient basis upon which to predict the future of the pineapple here either for canning or for fresh fruit shipping but the evidence so far in hand seems favorable to the growth of both the Cayenne and the Spanish as well as other varieties. It is hoped to increase the plantings of the most promising varieties, to a sufficient degree to make possible their dissemination in small lots so that they may be tried under a wider range of conditions.

BANANA.

The work that has been done with bananas at this station has centered chiefly around the problem of disease-resistant varieties. There are three varieties under cultivation here which are recognized among scientists and banana growers as possessing a high degree of resistance. There is no evidence on this subject available from the records of observations here, because the disease is not present in this immediate locality so far as observed. The aim has been to maintain the resistant varieties and to multiply the plants so far as there might seem to be a demand for them. This demand, however, has not been keen during the past year as most of the banana shipping companies have not had satisfaction in handling the fruit of any of these varieties and prefer to buy the Gros Michel, which is the standard commercial banana of Central America and the West Indies. This leaves the growers confined chiefly to local markets to dispose of any other varieties and the capacity of these markets is very limited. However, it is recognized that some of the varieties have merit, that further investigations of their characters are necessary and that they may yet be of use in the industry. Hence they are being retained and held under observation.

One of the varieties is the Bungulan of the Philippines, known locally, but erroneously as "Lacatan." It is very desirable that this misnomer should be discontinued as it will give rise to confusion. The Lacatan is an entirely different fruit which no one could fail to distinguish if the two varieties were side by side. Without going into a minute description, it may be said that Lacatan has a golden yellow skin of even deeper hue than the Gros Michel, while the Bungulan is seldom as

bright as the Gros Michel and frequently ripens while the skin remains quite green, although at times, if the fruit is allowed to become quite full, it assumes a good color. In the Philippines, it is usually seen in the markets as a green-colored fruit, although soft and ready for use. In fact it is so rarely seen otherwise that it is spoken of as a green colored banana. In color of flesh, the true Lacatan is orange yellow while that of Bungulan is cream-colored or almost identical with the color of Gros Michel. These two contrasts in color of skin and of flesh are sufficient in themselves to mark the two Philippine varieties as wholly different. The flavor and aroma are quite as widely different but these are characters that do not admit of accurate description.¹ So far as the writer is aware, there are no Lacatan bananas in the Canal Zone although both of these Philippine varieties are believed to have been introduced into Central America.

The discussion of nomenclature need not be further prolonged. The adaptability of the Bungulan to purposes of the great banana trade is more vital and important. The Bungulan has shown a high degree of resistance to Banana Wilt wherever this variety is known to have been planted. It is a vigorous plant and produces large bunches of fruit which so closely resembles the standard commercial variety as to require a trained eye to distinguish the two in the green state and Bungulan frequently has been sold as Gros Michel. When ripe, if the Bungulan has ripened to a good color, they would pass, under the inexperienced eye, as Gros Michel. In flavor also few persons would recognize any difference. But the Bungulan, so far, has not ripened in a manner wholly satisfactory to the trade. Sometimes it has failed to color well, although in respect to color, it here, far exceeds its reputation in the Philippines. Also it has shown a tendency to ripen suddenly throughout the entire length of the bunch, whereas the trade desires a bunch that will ripen gradually. Some complaints have been made of its falling from the bunch. On several occasions, bunches of Bungulan and of other varieties, have been brought into the laboratory and hung up for observation during the ripening process. The Bungulan in these instances has attained a fair color and has held to the bunch while still very ripe. As the fruits become very ripe, some decay has extended from the stem of the bunch to the stems of the fingers but the latter have held to the bunch. Further and careful studies should be made on the ripening of Bungulan to determine whether any practical means may be devised for handling it, so as to overcome the objections that have been raised to it.

¹For more minute botanical description of Lacatan and Bungulan, see Quisumbing y Arguelles "Studies of Philippine Bananas." Philippine Agr. Rev. XII, No. 3. Also Teodoro, N. G., Philippine Journal of Science, Section C. 10: 400 and 405-406 (1915).

The Cavendish (*Musa cavendishii*) is a distinct species. It is variously known to the trade as the Chinese banana, Dwarf, Canary Island, etc. This possesses a high degree of resistance to the disease, yields well, is vigorous and less subject to wind-injury than the taller growing plants. But the bunches do not endure shipment well without a protective covering of dried banana leaves or other material, as is provided for them in Hawaii, the Canary Islands, and other places when they are grown commercially. This adds materially to the cost of handling them and they are not likely to take a prominent place in the Central American banana business so long as it is possible to grow enough Gros Michel to supply the demand. However, the Cavendish may be considered as a reserve resource upon which the banana industry could be maintained in the event of the Gros Michel being eliminated.

CITRUS FRUIT.

Nearly all of the citrus trees in the Gardens made a satisfactory growth during the rainy season of 1927 but were much retarded in their progress by insufficient water during the dry months from January to May, 1928. Heavy mulching with grass and the liberal use of stable manure has helped much to carry the trees through the dry season. Since the rains have begun they are making excellent growth and many are fruiting.

At Juan Mina plantation, on the east bank of the Chagres River, where there is a large citrus orchard of mixed varieties, under the control of the Cattle Industry, and the general direction of the Agronomist, the trees have shown a great diversity of success and failure. Practically all of the young trees, planted out during the past two years have been making satisfactory progress. Many of the old trees appear to have been in an unsatisfactory condition for a long time. Some trials have been begun with the use of chemical fertilizers to determine what may be done by fertilization to restore these trees. There is also a need of pruning and of spraying, far in excess of what can be done by the present force.

Some of the fruits that have come out of this orchard have been of excellent quality. This is particularly true of grapefruit of the Connors variety. Other varieties which at present are promising are the King Mandarin, the Valencia and the Lue Gim Geng oranges. In oranges, as in avocados, mentioned elsewhere, the arrow of success points toward those varieties which ripen when the markets are clear of cheap seedling fruit. In seedling season, oranges are very cheap but when the only oranges in the market are those imported from California or Florida, prices are very high and a first class orange or mandarin grown here and kept clean by spraying should sell for a good price.

THE PAPAYA.

The papaya has come to be almost a universal breakfast fruit in many parts of the tropics. Here in the Isthmus it is highly esteemed when a supply is available. The quality of the best selected fruits is excellent. At certain season of the year, however, it is almost impossible to get them as there are few in the market. The question is sometimes raised as to the cause of this dearth of papayas and how it may be overcome. A year of close observation of papaya trees will convince any one. The answer is water. Most papaya plantings have been made without any provision for irrigation. If the soil permits free drainage, the trees grow rapidly during the entire period of abundant rains, and begin to set fruit soon after they have revived from the drought. During the last half of the rainy season there is an abundant supply of good fruit and this continues into the first part of the dry season, so long as there is sufficient moisture in the soil to complete the development and the ripening of the fruit. Then follows a period when the partly developed fruit shrivels for want of water and falls from the tree. A few trees die. The others struggle along, dropping all their leaves except a few at the top. Growth practically ceases and no flowers are produced. The trees that have persisted begin to revive soon after the first rains, and a little later commence to produce flowers which will result in fruit when the rainy season is well advanced. Thus it is that the market is well supplied in the latter half of the rainy season and at the very beginning of the dry weather before the soil moisture is depleted.

Although it has not yet been possible to install an adequate irrigation system, arrangements were improvised for getting water to one end of the papaya orchard late in February and the trees in this location were kept fruiting through the dry season.

Any one contemplating the growing of papayas commercially on the Isthmus, should select a place where ample water can be secured and applied cheaply, thus providing for a supply of fruit during the season of high prices. As the trees live for several years, the exact month of planting is not vital.

Another important factor in successful papaya growing is the selection of seed. This should be taken from choice fruit from high-yielding trees of the kinds which produce bisexual flowers, as these latter tend to result in a minimum of staminate or nonfruit-bearing trees. Nearly all of the elongated type of fruits are from bisexual flowers. It is also to be remembered that there are very few, if any, well-established and strictly maintained varieties of papaya and the best seed available is likely to yield a somewhat variable product.

MANGOSTEEN.

This fruit which enjoys so enviable a reputation in the Malayan and East Indian regions was introduced into the Isthmus by Dr. David Fairchild of the United States Department of Agriculture. The first tree, which was planted at Frijoles, fruited in 1927 and the younger trees planted there are doing well. The mangosteen trees at the Plant Introduction Gardens are now making excellent growth and fruits have begun to appear. This tree seems particularly adapted to soils that are too wet for most fruit trees. They are slow in starting but after a few years, they make satisfactory growth, under conditions here, appear very healthy, and up to the present have been quite free from insect pests and diseases. Shade seems to be quite necessary when the trees are young to prevent sunburn. The trees at Summit are now without shade for the rainy season and do not seem to require any at least until the rains have ceased.

THE CARAMBOLA.

Azerrhoa carambola, Family Oxalidaceae.

The Carambola is a very unique and interesting fruit tree of South China or the Malayan region. It is of small size and produces handsome, yellow, star-shaped fruits of waxy appearance. When in full fruit there are few fruit trees that are so beautiful. The fruits are borne in clusters and hang like golden drops on the outside of the tree and also hidden among the leaves. Some varieties are quite sweet and are preferred by some people while others have a decided but pleasant acidity. All kinds may be eaten as fresh fruit or may be cooked, while the acid varieties are especially good for use in making fruit punch. The carambola trees at Summit have begun to bear and are vigorous.

GAS TREATMENT OF FRUITS.

The application of combustion gases to citrus and other fruits, for the purpose of coloring them, is now a well-established practice. The first method by which these gases were applied was from the exhaust pipe of gasoline engines or from smoking lamps or kerosene stoves. Although this method has been largely superseded by the use of ethylene gas, sold in drums, the older method is often convenient for those who may not find it easy to get ethylene in drums.

Some very successful trials were made, in the ripening of a small crop of green tomatoes, by the use of a smoking lamp. The crop was threatened with complete destruction by decay, apparently of fungus origin, which was not successfully held in check by spraying with fungicides, as these do not adhere well to the fruits during the heavy rains. The fruits were gathered while very green, and after eliminating those that appeared to be affected with the disease, the sound fruits were placed in a fairly tight cement chamber where an ordinary kerosene lamp with circular burner was lighted and placed without a chimney. The chamber was closed for three hours and then opened and ventilated for two hours, after which the lamp was lighted and the chamber closed until 7 a. m. on the following morning. After ventilation for two hours the treatment of the preceeding day was repeated. The light is extinguished after a few hours by the exhaustion of the supply of oxygen and the increase of other gases. After two days of such treatment, these tomatoes became thoroughly well ripened, assuming a color equal to vine-ripened fruits, and were apparently, in no way inferior in flavor which usually can not be said of tomatoes harvested very green and placed in the light to ripen. The latter frequently do not make satisfactory salad tomatoes.

Citrus fruits, including oranges, grapefruits, and lemons were treated by the same process, the periods of exposure being somewhat longer. The results were equally satisfactory in the coloring of the fruits. In these cases, the fruits were ripe and had developed their natural flavor before harvesting. There is no good excuse for harvesting immature citrus fruits as the gas process does not develop the natural flavor. Oranges and some grapefruits, particularly in the tropics, have a decided tendency to remain green in color after they have ripened on the trees. The gas process is valuable to induce the desired color but its use to color sour, immature oranges and grapefruits is culpable and, in the citrus growing regions of the United States, is forbidden by law.

The report of the above-mentioned demonstrations of the crude methods of applying gas is made here merely to indicate its simplicity and adaptability where the more recent methods are not available. If large quantities of fruit are to be treated, it would be advisable to get ethylene in drums.

ABACA.

(*Musa textilis*.)

There are few, if any, plant introductions of recent years that are so replete with possible significance not only to Panama but to the American tropics in general as the abaca. Indirectly, this may have a very definite bearing upon the volume of business of the Panama Canal. If the pro-

duction of abaca fiber, in the Americas, assumes large proportions, a part of the European demand which now is supplied from the Philippines via the Suez, may in the future, be furnished by Central America or South America. In such case any such portion, produced on the Pacific side would pass through the Panama Canal. Part of the supply for the United States and Canada might also transit the Canal.

It is well recognized that abaca fiber or "Manila Hemp," as it is known to the trade, is the most important of the world's cordage fibers, being far superior, for nautical use, to sisal which is its chief competitor. Until recently, there has been no commercial production of abaca outside the Philippine Islands. Within the last few years it is reported that the Dutch East Indies have established a small production and it is said that this industry is expanding.

The Canal Zone Plant Introduction Gardens are indebted to the United States Department of Agriculture for several introductions of abaca, including a number of the best-known varieties, and the Gardens have cooperated with the Federal Government in the effort to establish the plant here. The climatic and soil conditions, at Summit, are not well adapted to this culture but, by special care, it has been possible to maintain many of the plants and to multiply them sufficiently to make some disseminations. At Summit, the dry season is very trying to most of the varieties but some of the seedlings from the varieties Pula and Maguindanao are multiplying very satisfactorily. Fig. 1, below, shows some of these seedlings of Maguindanao in a moist location.



FIG. 1.—Abaca seedlings from seed of the Maguindanao variety. Two years, eight months old.

On the rich, deep soil, used for banana culture, in the regions of constant rain, very much superior results are to be expected, for these locations seem to present conditions similar to those under which abaca has reached its highest perfection in Davao, Mindanao, Philippine Islands. Most encouraging advices have been received by letters from the office of Fiber Investigations of the United States Department of Agriculture which indicate that several varieties are doing remarkably well at Almirante, Republic of Panama, where fiber has been produced that compares favorably with the best Philippine grades. Nearly 50 acres have now been planted. As some of the varieties are reported to be highly resistant or immune to the disease that has been serious in the banana industry, it is possible that abaca may furnish another means of utilizing these lands where large capital is already involved.

The Plant Introduction Gardens will continue to cooperate, to the fullest extent possible, as a medium for the distribution of abaca plants to localities in which it may become of commercial importance.

CHAULMOOGRA OIL TREES.

All of the different species of trees that have been planted as possible sources of oil, for use in the treatment of leprosy, have been under observation. The most extensive planting of any of these is the eight acre plantation of *Taraktogenos kurzii* planted in June, 1924, at Flat Rock on the east bank of the Chagres River, and north of Juan Mina. These trees are growing well, many of them being 12 to 15 feet in height. (Plate V, Fig. 1.) One or two flowered during the year but no fruit resulted as is frequently the case with the first flowers. The results, attained at Flat Rock, are quite encouraging so far as the general appearance of the trees is concerned. Some of these trees are under the shade of banana plants and others are exposed to full sunlight. It has not been possible to detect any differences in favor of the shaded or nonshaded trees. The trees have received during the year no fertilizing, no watering, and no other care except the cutting of the grass and the leaves of encroaching banana plants. At Summit, none of the trees of *Taraktogenos kurzii* have made satisfactory progress, although they have received the same care as other trees about them. The heavier rainfall at Flat Rock is doubtless in favor of the trees there.

Likewise neither of the species of *Hydnocarpus* at Summit has been making the development which is desired. These species include *H. anthelminthica*, and *H. wightiana*. Whether these results are wholly due to dry season conditions has not been determined.



FIG. 1.—*Turkioyenos Kurzii*. Tree, three years and seven months from planting.



FIG. 2.—*Coffea excelsa*. Tree, four and one-half years from planting. Yield—three pounds parchment coffee.

The plantings of *Oncoba echinata* at Summit have made a very much better growth. These trees, of which there are 75 in all, probably average about 12 feet in height. Many of them have produced a small crop of fruit. The Agronomist was shown a small planting of *Oncoba echinata* in the experiment gardens of the United Fruit Company, in Costa Rica, at an elevation of perhaps 1,000 feet. These trees were much larger than those at Summit and had a most abundant crop of fruit at the time. The conditions of soil and climate at this place seemed to be ideal for this tree. It is understood that the value of the esters derived from the oil of the seed of *Oncoba echinata* has not been determined. Should it prove to be as efficacious and as satisfactory as the esters from the oil of the seed of *Taraktogenos kurzii* or of some of the species of *Hydnocarpus*, there would seem to be no difficulty in producing an abundant supply of *Oncoba* seed in a comparatively few years, as these trees come into bearing in 3 or 4 years.

COFFEE.

There is probably an acre or two of the Gardens planted to several species of coffee. These include *Coffea excelsa*, *C. arabica*, *C. robusta*, *C. canephora*, *C. columnaris*, *C. dybowskii*, *C. laurina*, and *C. liberica*. All of these grow very well during the rainy season but during the dry weather some suffer much for water. Several of these flowered profusely but were not able to set a crop of fruit. One tree, recorded as *Coffea excelsa*, shown in Plate V, Fig. 2, produced in February, an excellent crop of coffee, for a tree only four and one-half years planted. This crop weighed 3 pounds in the parchment, estimated to be two and one-fourth pounds as cleaned coffee. This tree may have received a little more moisture than some of the others but in no case was it possible to supply sufficient water. Most of the seed of this tree has been planted for further trial, in those parts of the lowlands of the Isthmus where the dry season is less severe and where a coffee variety, capable of producing well on the lowlands, might be of value.

Attempts are being made to get from Hawaii, a strain of the Arabian which seems to prosper and yield a good crop of high quality coffee at comparatively low elevations.

RUBBER PLANTS.

Trees of Para rubber, *Hevea brasiliensis*, are to be found in many parts of the Gardens. Some of the oldest of these, received as seed in November, 1924, now range from 18 feet to 21 feet in height. One of these, in a mango nursery, is shown in Plate VI. In general their growth has been such as to encourage further and more extensive trials.

PLATE VI.



Para Rubber Tree to left of center and in background. Grafted Mango Trees in nursery and two in cement tubes. Note the much stronger growth of those in nursery row.

Cryptostegia grandiflora is a most vigorous vine and highly ornamental, with its profusion of purple bell-shaped flowers. It is worthy of more extended use as an ornamental. It abounds in latex and if efforts should become successful in devising a practical machine for the extraction of the rubber, it may become of great economic importance, as it thrives under conditions quite unsuited to *Hevea*, which is the chief source of commercial rubber.

JAVA GRASS (POLYTRIAS PRAEMORSA.)

This grass which was introduced from Porto Rico in June, 1923, is spreading rapidly. Although very fine and soft in texture and usually only a few inches high, it is able to contend with most of the wild grasses and establish itself if plantings are made here and there in the fields. No evil effects of its growth have yet been observed and, although trees surrounded by it can not be expected to do as well as with legumes, the Java grass is far preferable to the rampant growth of wild and high-growing grasses. In dry season, Java grass dries back to the ground, if not watered but springs up immediately with the coming of the rains. If used for a lawn, and kept supplied with water, it grows well through the dry weather, uninjured by sun or dry atmosphere.

The demand for planting material of Java grass is increasing rapidly. About 600 sacks of cuttings have been distributed during the year. It is being used for lawns, for golf courses, and also for aeroplane landing fields. It is not yet known how well it may endure the severe wear of landing planes but it appears to be the best grass available at present for the purpose under such conditions as exist here. The method, now being used, consists in planting bunches of three to six cuttings at distances of 8 to 12 inches apart. The plant seeds freely and seed planting should be tried out.

SOME FLOWERING TREES.

Several species of very highly ornamental flowering trees have arrived at sufficient maturity to flower. Among these may be mentioned *Cassia nodosa*, commonly known as the "Pink and White Shower." There are few, if any, of the trees grown for their flowers, that are so magnificent as this species of *Cassia*. Its near relative, *C. grandis*, also of remarkable beauty, is making excellent growth. Several species of *Lagerstroemia* have flowered profusely, including *L. flos-reginae*, *L. speciosa*, and *L. thorelli*. These handsome trees with their large pink-purple and lavender flowers will add greatly to the beauty of the plantings about the Canal Zone and elsewhere in Panama as they become widely disseminated.

PLANT ACCESSIONS.

Since the opening of the new accession book in June, 1927, 879 accessions have been added to the list of plants in the Gardens. Many of these are entirely new to the Isthmus. Space will not permit even a list of such new introductions but brief mention may be made of a few.

The largest and most unusual collection of plants received from any one source during the year was that brought here on January 14 by Mr. Allison V. Armour and party on his yacht *Utawana*. The plants were in the immediate care of Mr. P. H. Dorsett of the United States Department of Agriculture. These rare plants were collected in various parts of the tropics by the Armour Expedition for plant explorations, under the technical direction of Dr. David Fairchild of the Federal Department of Agriculture. Included in the 93 different species of plants in this lot brought to the Canal Zone Gardens, were several species of *Garcinia* that may be of value in mangosteen propagation; *Lansium domesticum*, the Langsat or Lanzone, one of the most highly prized fruits of the Malayan region; three strains or varieties of *Elaeis guineensis*, the African Oil Palm which are reputed to produce seeds of unusually high oil content; two species of *Canarium*; and many other unusual plants of rare interest and much promise.

Seed of the Giant Bamboo, *Dendrocalamus giganteus* has been received from the Royal Botanic Gardens, Peredeniya, Ceylon, and a pleasing lot of seedlings are now in the propagation house and should serve to establish this valuable bamboo in the Isthmus.

An extensive collection of Hawaiian varieties of hibiscus has been received from the Hawaii Agricultural Experiment Station and others from the Federal Experiment Stations in Porto Rico and the Plant Introduction Garden, at Chapman Field, Fla. In recent years, amateur and professional breeders in Hawaii have produced several thousand varieties, including many of exquisite beauty.

We are indebted to the Missouri Botanic Gardens for a very unusual collection of tropical water lilies, *Nymphaea*, which were brought by Mr. G. H. Pring. Most of these are hybrids, originated by Mr. Pring in St. Louis. They will add greatly to the beauty of the Gardens. A pond of *Nymphaea* is shown in Plate II, Fig. 1.

Dr. Harold L. Lyon, of the Experiment Station of the Hawaiian Sugar Planters Association, called here en route from Trinidad to Hawaii, which offered another opportunity for valuable exchanges. Dr. Lyon left, among other things, a collection of orchids that are new to Panama.

Collections of the best varieties of upland rice have been received from the Bureau of Agriculture and from the College of Agriculture of

the Philippines. All of these are doing well. From the College, two varieties of corn well adapted to tropical conditions, have been received as well as Pili nuts, palms, and other things mentioned elsewhere.

One hundred seeds of the best selected varieties of dates have been received from Dr. Walter T. Swingle of the United States Department of Agriculture. These have shown excellent germination. While it is not thought conditions anywhere on the Isthmus are favorable for commercial date culture, it is hoped that some of the varieties will produce good dates for eating in the fresh state. The date is worthy of a place here for its ornamental value and shade even if it should never yield fruit.

Seed of *Guaiacum officinale*, the true Lignum-vitae has been received from the Hope Gardens, in Kingston, Jamaica. By means of this seed, it is hoped to disseminate the species widely.

A large collection of very beautiful caladiums was received in excellent condition from Dr. H. Nehrling of Tamiami Trail, Naples-on-the-Gulf, Fla.

An effort is being made to get together as large a collection as possible of the leguminous green manuring crops and cover crops for soil improvement and the control of rank-growing grasses that interfere with the progress of trees and shrubs. This collection has received increment from the United Fruit Company in Tela, Honduras, from the Department of Agriculture in San Juan, Porto Rico; the Porto Rico Agricultural Experiment Station; the University of Hawaii, the United States Department of Agriculture, the Instituts Scientifiques de Buitenzorg, Buitenzorg, Java, and other sources.

Among other plants may be mentioned the Philippine Kapok or "Silk Cotton" tree, which produces one of the best mattress fibers known; *Myristica fragrans*, the Nutmeg; a selected variety of *Casimiroa edulis*, the White Sapota, a fruit now receiving considerable attention in the tropics and subtropics; *Canna edulis* or edible canna, now being grown as a commercial source of starch; several interesting and beautiful palms from the Philippines; several varieties of citrus and of avocado from Florida and from California; *Butea frondosa*, a tree yielding a gum or lac of commercial importance in India; *Aleurites Fordii*, the China Wood-Oil Tree, now of increasing commercial importance, because of the value of the quick-drying oil for use in paints and varnishes; also the related species, *A. trisperma*, yielding an oil of similar character; *Canarium luzonicum*, the Pili nut of the Philippines which is one of the most pleasing nuts now in commerce; *Durio zibethinus*, the Durian from Malay and the East Indies; and many others might be added. Thanks and appreciation are hereby expressed to all of the institutions that have been mentioned for these and many other valuable accessions.

Seeds or plants of great interest and value have been received from the Harvard Botanical Gardens, Soledad Estate, Ceinfuegos, Cuba; the Forest Research Institute and College, Dehra Dun, U. P., India; the Royal Palm Nurseries, Oneco, Fla., and other institutions and individuals, too numerous to be mentioned here. For all of these opportunities for plant exchanges, it is desired to express our thanks and appreciation.

The Canal Zone Plant Introduction Gardens will welcome the opportunity to enter into exchange relations with other botanic gardens, agricultural departments and experiment stations in foreign countries.

A feature of the plant accessions upon which some emphasis is being placed is the bringing into cultivation of indigenous plants of economic or of ornamental value. Among such might be mentioned *Pogonopus speciosus*, *Warscewiczia coccinea*, *Aphelandra sinclairiana*, *Calycophyllum candidissimum*, *Odontadenia speciosa* and many others. These are also being grown in sufficient quantity for dissemination in the Isthmus. Very many species of ferns, indigenous to this region, are being brought into cultivation.

PLANT DISSEMINATION.

During the 12 months of the fiscal year, there were distributed 11,700 plants and about 700 sacks of grass for planting purposes. Plate VI shows one of the mango nurseries maintained for plant distribution. A part of this distribution was sold at nominal rates far below the cost of producing the plants and the balance was given out without charge, chiefly to district quartermasters and to different organizations of the United States Army and Navy. The demand for grafted or budded fruit trees at the nominal prices charged, has been far in excess of the increased supply. As there seems to be a call particularly for such trees as oranges, grapefruit, avocados, mangoes, and other fruits, in hundred lots and in some cases by thousands, and as there appears to be no commercial source of supply, it has been decided to try to meet a part of this need by increasing the production of nursery stock and charging a higher rate so as to approximately cover the costs. The purpose is distinctly not that of making a profit but rather to aid in the dissemination of valuable plants which can not be obtained elsewhere in this country.

REPAIRS AND IMPROVEMENTS.

A special allotment of \$4,375 for the repairs and reconstruction of buildings was made by the Governor of The Panama Canal, upon recommendation of Mr. Roy R. Watson, Acting Chief Quartermaster.

Practically all of the plant houses were much in need of repair. The general work room for plant propagation has been repaired and partly reconstructed by the installation of concrete bins for soil, sand, peat, compost, and other materials and also a long concrete work bench. A steam boiler has been installed for the sterilization of soil, the steam being conducted into three tight soil bins. The glass house has been entirely rebuilt and refitted with benches and a concrete propagating trough. There has been constructed one shade house in which strips of corrugated iron approximately 6 inches wide, set 6 inches apart, have been used to provide half shade. Another house about 150 feet long by 25 feet wide has been constructed of 2-inch pipe for a frame work. This pipe work is connected with wire about 18 inches apart on the roof and 12 inches on the sides. This is to be used as a support for permanent vines which will afford the shade necessary and should last for many years. Other shade houses are now being repaired. It is fortunate that, in all of these houses, the original concrete floors and foundations were still intact.

Considerable road repairs have been made from funds of the regular allotment. The main concrete road through the Gardens was repaired in many places and in part has been covered with a slab of new concrete. The chief macadamized road has been surfaced and oiled. There is need of further road repairs and new construction when funds are available.

INCREASED HOUSING SPACE.

At the close of the fiscal year, an additional suite of rooms was set aside to increase the space for office, laboratory, and library purposes. This doubles the floor space by making the entire first floor of Building No. 7 available for such uses and thus fills a pressing need.

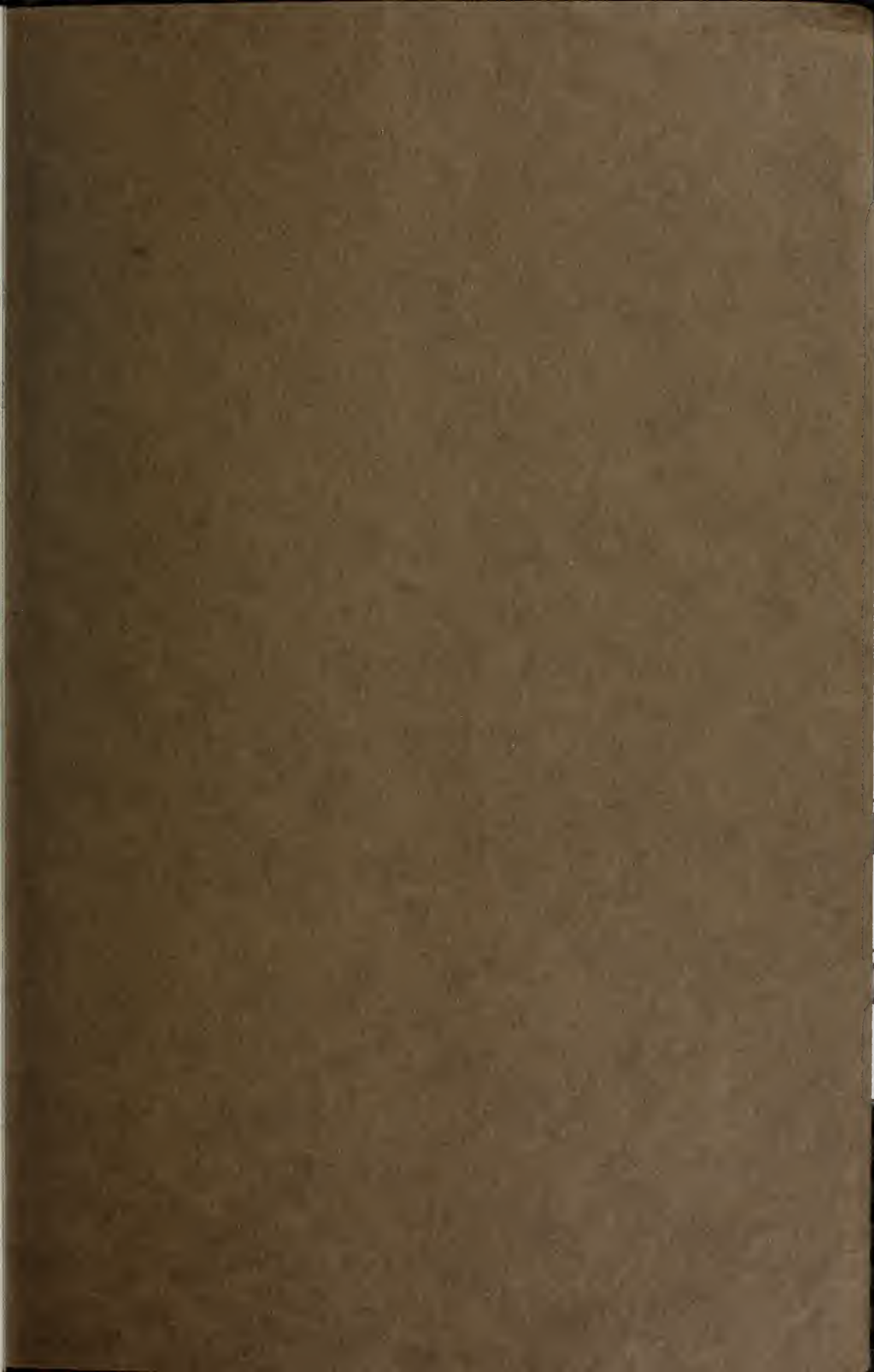
FURTHER ACKNOWLEDGEMENTS.

Acknowledgment and thanks are due to the official photographer of France Field for the photograph used in Plate I; and to the Commanding General of the Panama Canal Department of the United States Army, for permission to use this photograph in publication. It is also desired to express appreciation of the services of the Official Photographer of The Panama Canal in supplying photographs for use in Plates III, IV, VI, and Fig. 1, and many other excellent photographs for the records of the Gardens.

NEEDS.

The most pressing need at the Gardens is an adequate irrigation system. The pipelines and the pumping plant are insufficient to convey the needed water and many plants are damaged by the dryness of the soil which opens in large cracks, exposing roots and often breaking them. Plans for a very much enlarged system of irrigation have been submitted.

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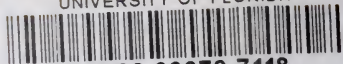
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